HYDROLOGY

Precipitation

At this latitude precipitation in the form of rain or snow is affected by temperature, which has an annual mean of 42E F. Rain has the effect of quickly recharging groundwater and surface water, where snow melt has a gradual effect on surface water hydrology. The average annual precipitation at Hermann, MO (lower watershed), Rolla, MO (east middle watershed), Jerome (middle watershed) Lebanon (west middle watershed), Houston (upper watershed), Marshfield (upper watershed) was 40.35, 41.09, 41.76, 41.37, 42.70, 42.67, respectively, inches over the period 1961-90 (Owenby and Ezell 1992). The arithmetic watershed precipitation mean is 41.66 inches.

US Geological Survey (USGS) water discharge gage stations are shown on Figure 10. These stations collect daily water discharge data, and some stations house National Weather Service gage-height meters. The following is a list of the location and period of record of the gage stations.

Gage Station	Stream	Location	Comment	Period of Record
06932000	Little Piney Creek	Lat. 37E54' 35", long. 91E 54' 12" in SW 1/4 SE 1/4 sec. 22, T37N, R9W	located on the left bank at downstream side of bridge on State Highway P and T at Newburg, and 2 miles upstream from Mill Creek.	October 1928 - present
06933500	Gasconade River	Lat. 37E55' 47", long. 91E 58' 38" in NE 1/4 NE 1/4 SE 1/4 sec. 13, T37N, R10W	located on the left bank at Jerome, MO, 0.5 miles downstream from Little Piney Creek, and at river mile 107.	January 1923 - present
06934000	Gasconade River	Lat. 38E23' 20", long. 91E49' 15" in SE 1/4 sec. 16, T41N, R8W	located downstream side of State Highway 89 Bridge, 100 feet downstream from Brush Creek slough, 800 feet upstream from Swan Creek, and 4 miles east of Rich Fountain.	1921-1959 and October 1986 - present

06928440 (water quality)	Roubidoux Creek	Lat. 37E49' 30", long. 92E11' 53" NE 1/4 NW 1/4 sec 25, T36N, R12W	at Waynesville	1993-present
06927800	Osage Fork, Gasconade River at Drynob	no longer active		1962-81
06928200	Laquey Branch near Hazelgreen	no longer active		1958-72
06928500	Gasconade River near Waynesville	no longer active		1914-71
06928000	Gasconade River near Hazlegreen	no longer active		1928-71

Numerous inactive surface water-quality stations are listed in the *Water Resources Data of Missouri* (United States Geological Survey 1998).

Using information derived from 7.5" topographic maps by Funk (1968), permanent and intermittent stream reaches within the Gasconade River watershed were tabulated (Table 7). The USGS defines perennial or permanent streams as those having water 12 months of the year during normal precipitation. According to Funk (1968), out of 271 total stream miles, the main stem Gasconade River watershed has 263 permanent stream miles capable of supporting angling. Third Creek, Roubidoux Creek, and Little Piney Creek have several miles of intermittent pools. Roubidoux Creek has several miles of losing stream segments, giving this stream approximately 25 miles of intermittent pools.

With increasing precipitation, monthly mean stream discharge rates climb in the late fall to early winter, followed by a March to May increase. Averaged over the 75-year period of record of the Gasconade River, April has the largest mean discharge rate of 4,682 CFS (Figure 11). It was this same month that the maximum mean discharge rate of 20,450 CFS was set in 1945. June was also a month of high discharge, having a maximum mean discharge of 18,500 CFS. The decay portion of the monthly mean discharge is known as the summer recession. At this time the 7-day low flows are recorded as discussed below. Groundwater storage is the major supply for river flow during the summer recession.

Over the period of record of 75 years, the annual mean discharge, averaged over the 12 months, was 2,663 CFS. The highest recorded annual mean discharge, set in the flood year of 1985, was 6,491 CFS,

and the lowest mean discharge, 544 CFS, was recorded in 1954.

Although many factors affected surface runoff in the Gasconade River, an obvious major contributor was precipitation patterns. From smaller to larger catchment, annual surface runoff was 11.22, 12.94, and 13.3 inches over the period of record at the Newburg, Jerome, and Rich Fountain gages, representing an approximate drainage area of 199, 2,840, and 3,180 mi^2, respectively. The average annual precipitation for the years 1961-90 was approximately 41 inches/year (Owenby and Ezell 1992).

A 3-year moving average of precipitation (inches) at Jerome, Missouri over the 1960-96 period of record provided a method of smoothing the data to help in pattern recognition. Precipitation for the 1960-96 period of record indicated that the winter seasons and growing seasons (April to November), as defined by the SCS Wright County Soil Survey, had year to year cyclic patterns (Figure 12). Overall, linear regression of winter season precipitation and the growing season precipitation over this period revealed a slight decline in winter season precipitation but no growing season precipitation change. No data were collected for certain years. For example, the USGS surface runoff data in Figure 13 was missing the 1985 precipitation peak, a flood event.

Figure 13 depicts the seasonal relationship of precipitation and surface runoff and the importance of vegetation to lessen the quantity of surface precipitation runoff. The beginning of the growing season has elevated rainfall and runoff. With the growth of vegetation, surface runoff declined only to raise with water uptake reduction by plants and the resistance to over-land water flow in late fall.

The linear regression lines provided a baseline to compare average year-to-year precipitation and runoff patterns (Figure 12 and 14). During the 1960s to the early 1980s, average precipitation intensified in the growing season and declined during the winter season. A pattern that appears normal. On the contrary, a pattern of increasing precipitation in the 1970s during the winter season (Figure 12) directly influenced the high surface runoff during this period (Figure 14). This winter pattern could be detrimental to soil integrity as soil erosion is influenced by surface runoff rates. While winter precipitation showed a general decline, linear regression of mean surface runoff is increasing steadily.

Several changes were evident from the 3-year moving average of both winter and growing season runoff. 1) Average runoff had greater extremes from late 1970s to the present than during the 1960s to the late 1970s. 2) Low winter season average runoff that was evident in the 1960s did not compare to low winter season average runoff in the 1980 and 1990s. 3) Low growing season precipitation in the late 1980s did not produce the same low growing season runoff that occurred the late 1960s (ranging between an average of 1.4 and 5.25 inches), which during the 1960's had nearly twice the winter and growing season precipitation. 4) Dry growing seasons of the 1980s to the 1990s may have been responsible for the elevated runoff in the winter seasons (Figure 14). For the 1960 - 1996 period, winter season precipitation was the lowest recorded in 1990, but winter season runoff in 1990 remained higher (Figure 14; mean of 8.6 inches) than any period during the 1960s to 1970s. In contrast, the dry growing season years of the mid 1960s (Figure 12) had lower winter season runoff (Figure 14; mean range of 1.4 and 5.25 inches), although the winter season precipitation was higher than previous years. Based on the evident changes in runoff, landscape factors other than precipitation in the 2,840 mi^2 catchment area, represented at the Jerome, Missouri Gage Station, are influencing surface runoff.

Over time, with no precipitation runoff to recharge the streams, discharge rate declined at a curvilinear rate. Base flow is defined as the dry-weather discharge of the stream, which is different from the low

flow of the stream that may include some surface runoff. For the period of record 1924-67 at the Jerome gage station (middle watershed), the minimum measured flow (one day value) was 254 CFS (Table 8). In addition, the minimum annual mean was 544 CFS. After ten days of no rain, the base flow receded from 600 CFS to 485 CFS, decreasing to 335 CFS after 40 days. Within the upper watershed, Osage Fork at Drynob had the lowest measured flow of 12 CFS. Beginning at 38 CFS, flow declined to 28 CFS after ten days and reached 11 CFS after a dry period of 40 days (Table 8).

The low flow characteristics of the perennial stream are influenced by the local geology of the watershed, primarily its soil retention and groundwater storage. Over a 20-year period, the lowest recorded 7-day Q_{20} (20 year) stream flow for the Gasconade River at the Jerome gage station was 299 CFS. Over a two-year period (Q_2), the discharge at the Jerome gage station (middle watershed) fell to 470 CFS for seven days, and every ten years (Q_{10}), discharge fell to 320 CFS for seven days (Table 9). Flow conditions inflate as water reaches the lower watershed at Rich Fountain, where the 7- day Q_2 fell to 520 CFS and the 7-day Q_{10}, fell to 330 CFS.

Good flow conditions are evidenced by the slope index (SI) of 1.57. Large SI values represent poor water supply and instability from year to year. In comparison, the Castor River and the Meramec River have SI values of 2.1.

At the Jerome USGS gage station discharge data has been collected for 75 years. Figure 15 shows the percentage of time that the flow equaled or exceeded a given discharge. Represented in the figure as log normal scale, Jerome gage station discharge exceeds 8,933 CFS for 5% of the time, 1,274 CFS for 50% of the time, and 448 CFS for 95% of the time. The gage is in the middle of the watershed and represents a large catchment. Flow conditions are good and discharge does not increase as quickly as other streams in Missouri.

At the Jerome gage station of the Gasconade River, the flow duration curve 90:10 ratio of the discharge value exceeded 90% of the time to the value exceeded 10% of the time is 520.4 CFS **:** 5,571.6 CFS or 1 to 10.7. Compared to the Meramec River, the 90**:**10 ratio for the Sullivan gage station, and the Eureka gage station was 271.0 CFS **:** 2,412.2 CFS or 1 to 8.90, and 520.7 CFS **:** 6,761.8 CFS or 1 to 12.97, respectively. These values suggest, as mentioned above, a lower variability in flow as compared to the Cuivre River that has a high 90:10 ratio of 1 to 218.

As published in Hauth (1974) the magnitude and the frequency of flooding was estimated for most Missouri streams. Hauth developed his mathematical technique for estimating the frequency of floods using 152 gage sites within Missouri's watersheds. Streams having a drainage area ranging from 0.1 to 14,000 mi^2 were included in the Hauth (1974) report. The estimated magnitude of floods for gages within the Gasconade River watershed is shown in Table 10. The 100-year flood event of the Jerome gage station would result in a discharge rate of 123,000 CFS. In addition, the probability of a flood happening in a given year is 1%. The decline in the discharge rate at Rich Fountain further upstream from Jerome gage station is due to the change in drainage area and gradient. Hauth (1974) developed equations to estimate the magnitude and frequency of flooding at ungaged sites. The basic regression model has coefficients that are specific to the frequency of flood years.

Dam influences on stream hydrology include cold or warm spillway discharge (depending on the spillway construction) and a gradient control effect. Fords or bridge crossing can act as gradient control and can affect fish passage. A large number of stream crossings exist in the upper watershed area (see

Land Use Section, Population). Within the Upper Gasconade River watershed USGS Hydrologic Unit Code (HUC) # 10290201, an estimated total of 83 lakes exist with an estimated total of 1197.6 acres. The Lower Gasconade River watershed, HUC # 10290203, contains approximately 35 lakes, totaling 787.9 acres (EPA Surf Your Watershed 1999).

While ponds continue to be built in the watershed, in the 1984 MDNR Water Quality Basin Plan only three lakes are listed as greater than 50 acres. These lakes are Lake Northwoods in Gasconade County, Peaceful Valley Lake in Gasconade County, and Brays Lake in Phelps County, which are 120, 170 and 162 acres, respectively, (MDNR 1984).

Information on impoundments can be found in the Fish and Wildlife Service National Wetlands Inventory (Cowardin, L. M. et al. 1979). These Palustrine wetlands are coded with the modifier impounded/diked (h) or excavated (x). PUBFh, PUBFx, PUBGh, PUBGhx, PUBHh, and PUBHx are some of the attributes (See Habitat Section).

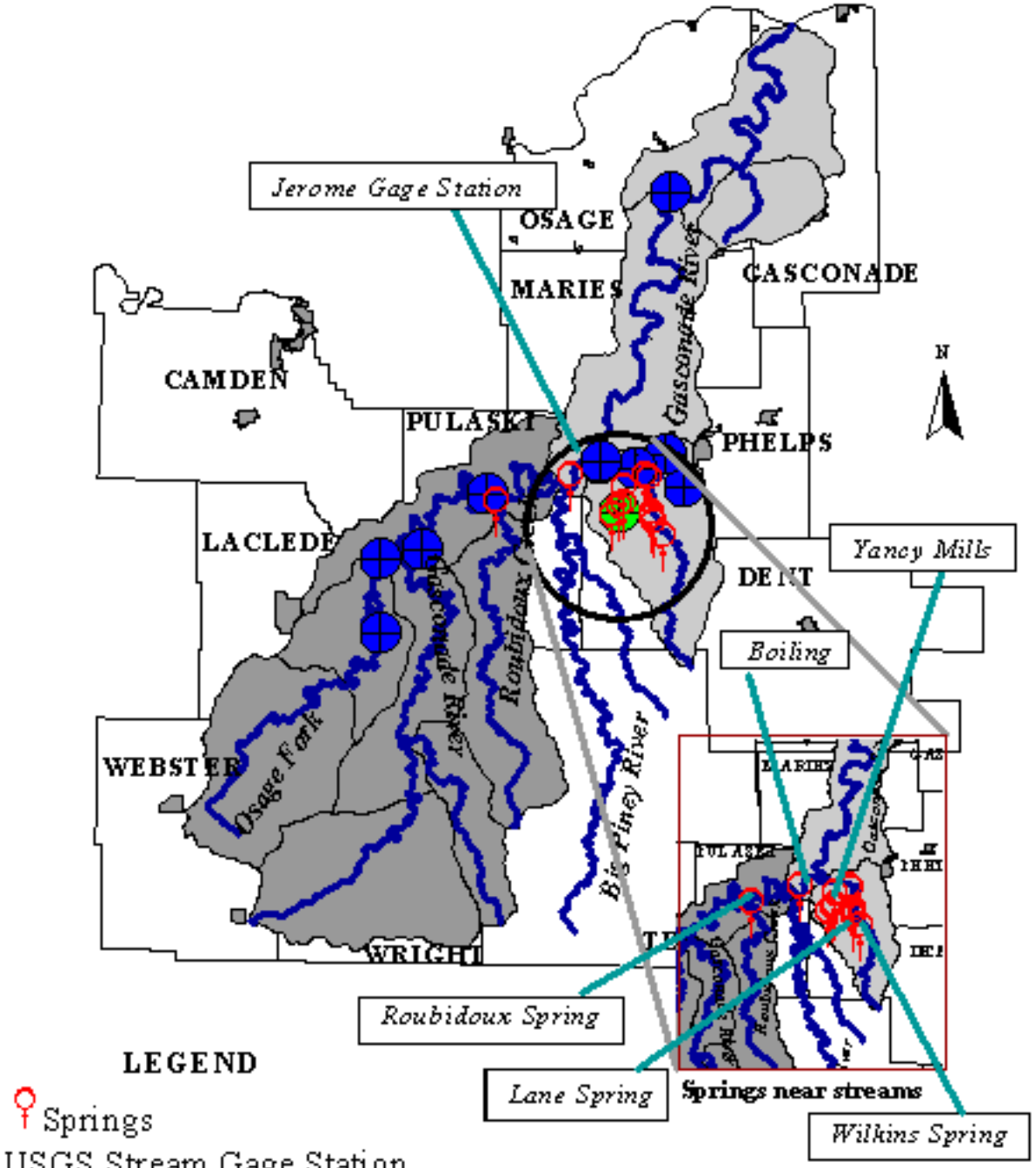
Cold Water Stream and Losing Segments

Because the Gasconade River watershed has a large concentration of springs, many areas have stream segments where water temperature is colder than the adjoining segments. Losing stream segments, springs, cold water stream segments have an unique relation due to the watershed's karst topography. Losing stream segments lose water flow to groundwater, only to contribute to a spring's discharge in some cases. Through unique hydrologic mechanisms, springs can contribute to a stream's flow thus creating cold water segments. The Upper and Lower 8-digit Gasconade River watersheds have several cold water segments that have been identified by MDC Fisheries Research (Figure 16 and 17). The Upper Gasconade River watershed has a segment near the mouth of Roubidoux Creek (Figure 16). The Lower Gasconade River watershed has three unique cold water segments in the Little Piney Creek Hydrologic Unit because of spring-rich topography (Figure 17). Little Piney Creek and Mill Creek have cold water segments for more than five miles. Mill Spring Creek is a small spring creek tributary to the Gasconade River.

General Hydrologic Data

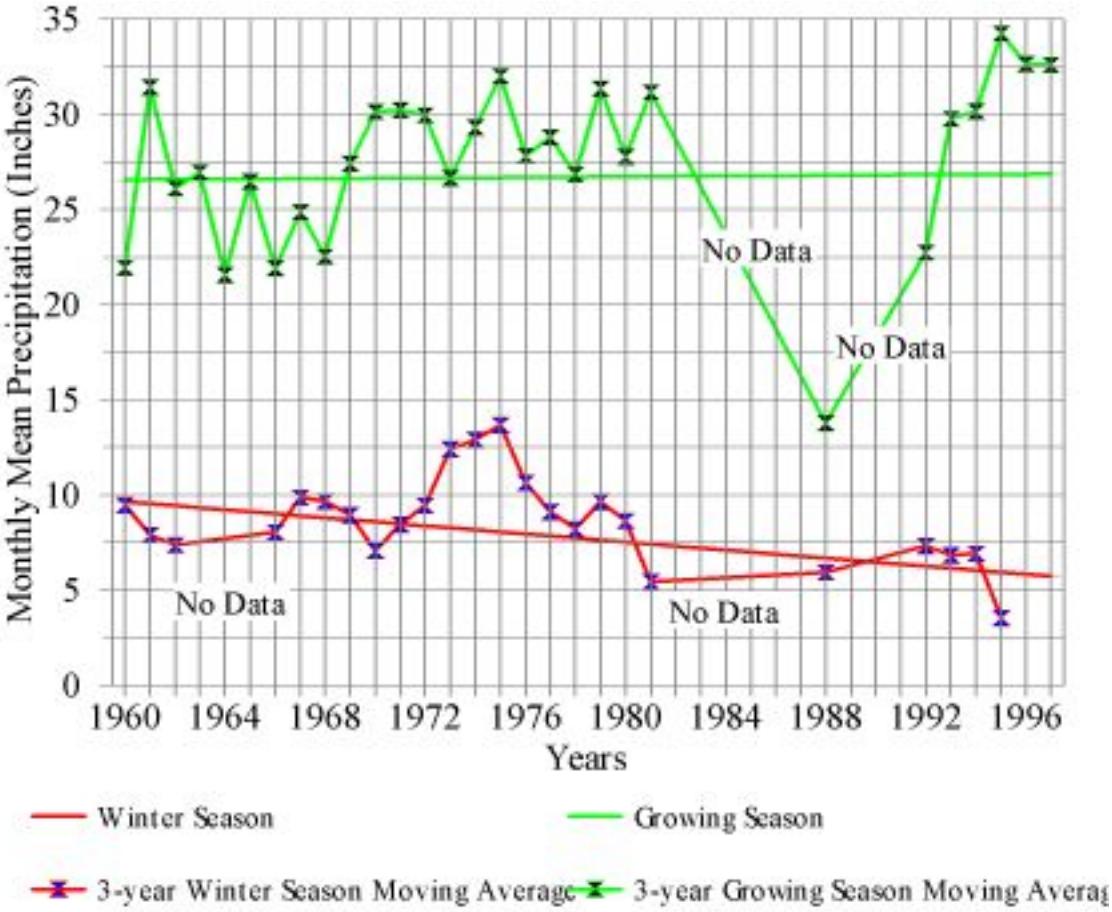
For more information on the hydrology of the Gasconade River watershed visit the USGS Water Resources site (HU # 10290201 or HU # 10290203).

Figure 10. Gasconade River Watershed USGS gage station (historic and recent) and springs.

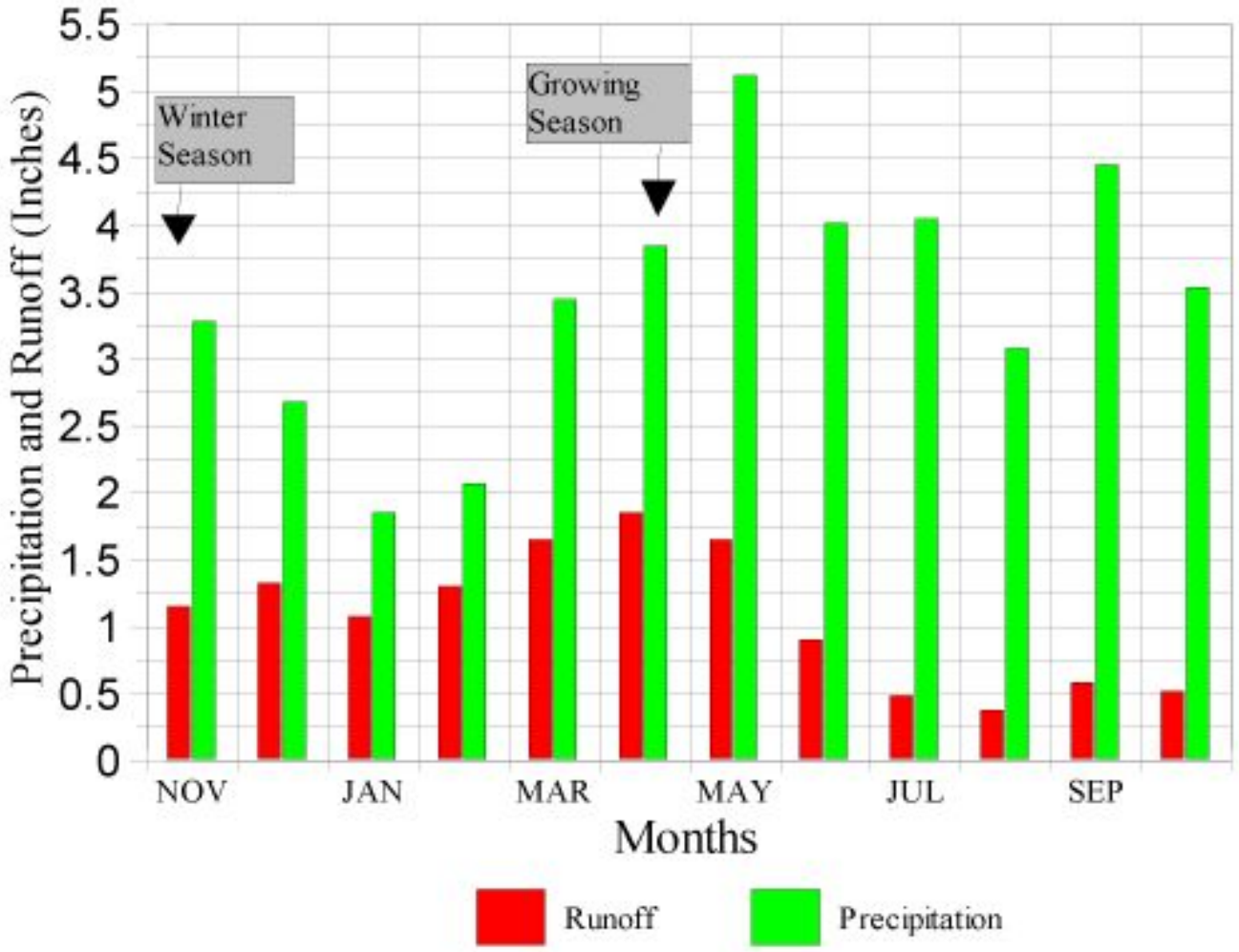


Sources: USGS 100k streams, Springs (Vineyard 1982).

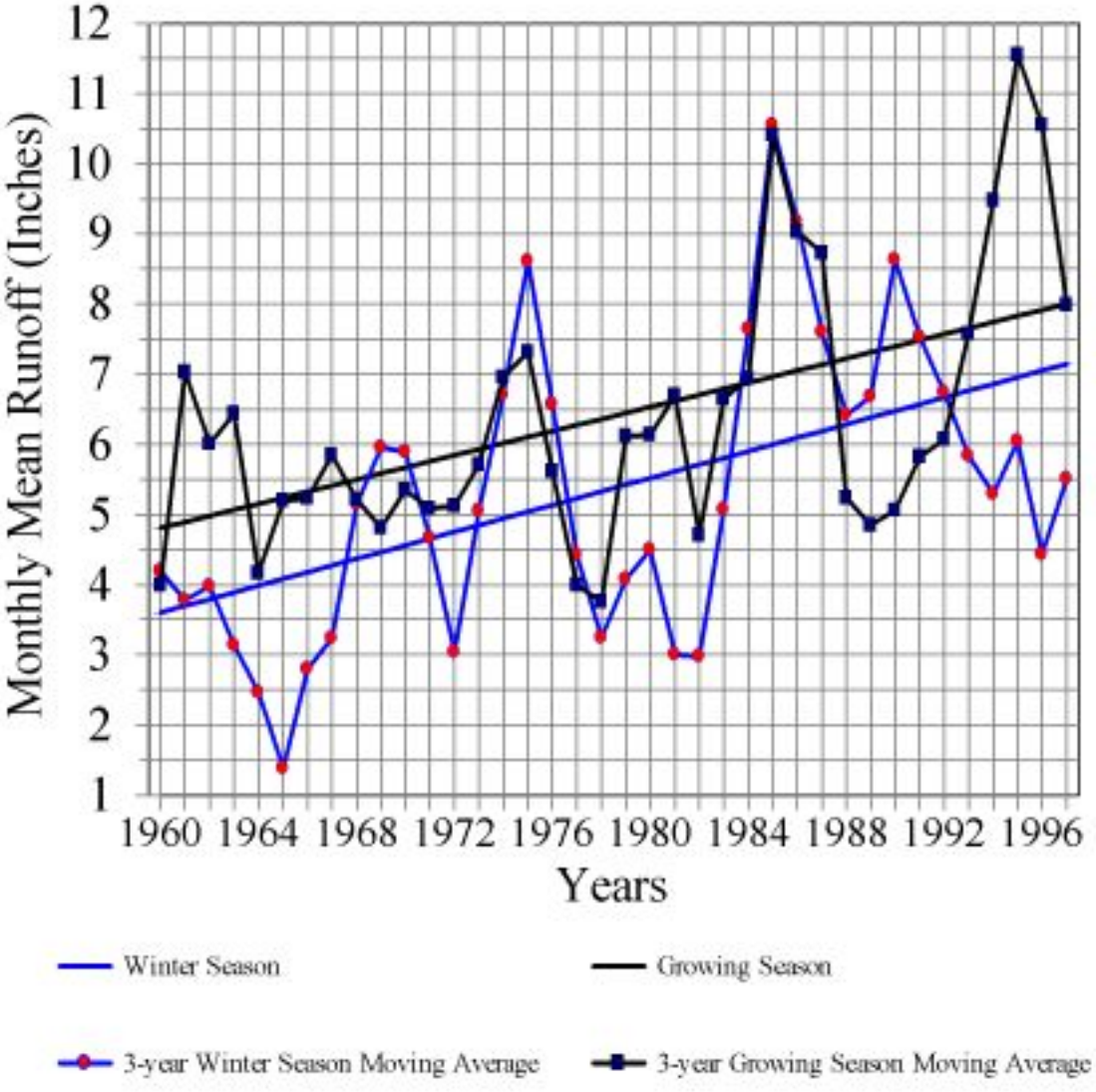
Created by: Todd Blanc 1998



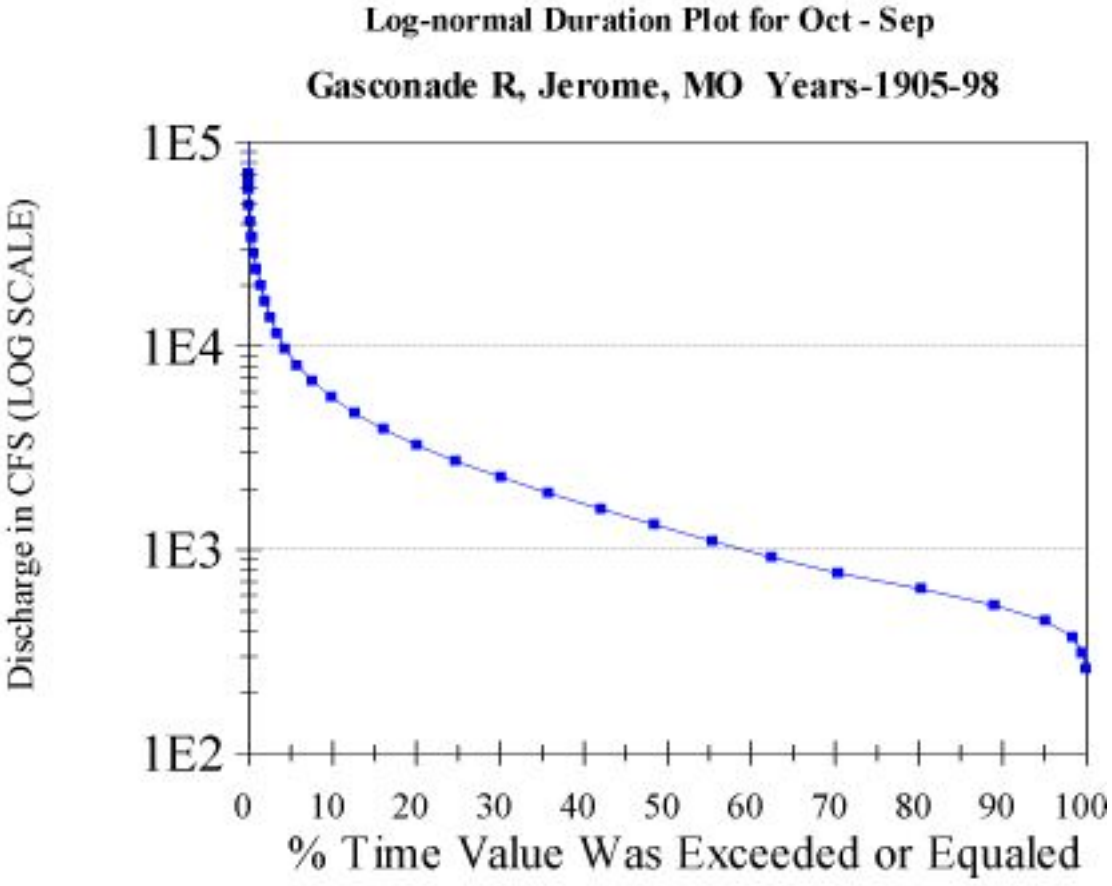
Winter season and growing season (April-November) precipitation linear regression lines and 3-year winter season and growing season moving average.



Monthly mean precipitation and runoff versus years from 1960-70. Bar chart of winter and growing season is shown.



Monthly mean runoff versus years from 1960-97 measured at the Jerome gage station of the Gasconade River watershed.



Gasconade River low flow duration plot for the years 1905-98.

Figure 16. Coldwater and losing stream segments within the Upper Gasconade River watershed.

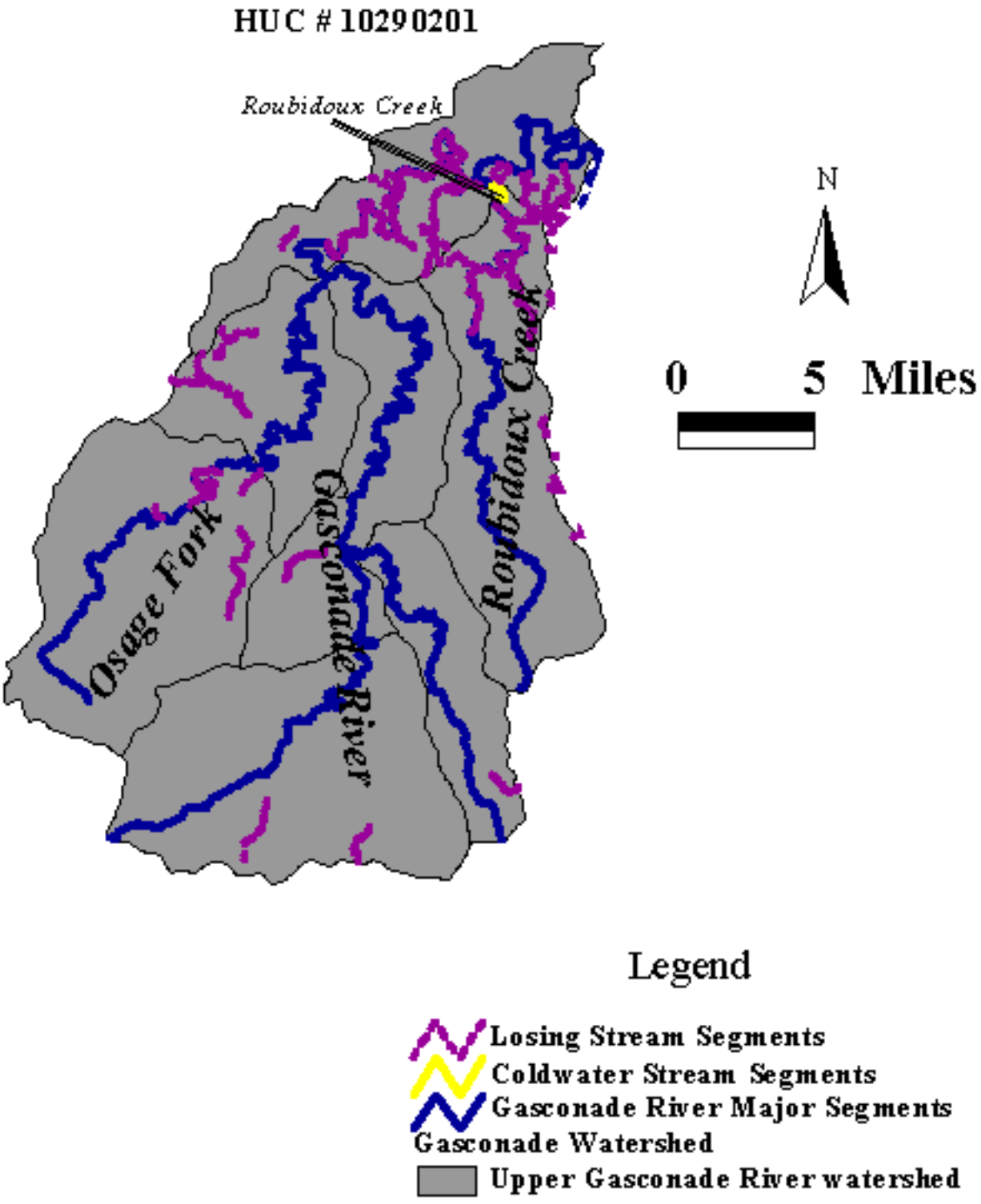


Figure 17. Coldwater and losing stream segments within the Lower Gasconade River watershed.

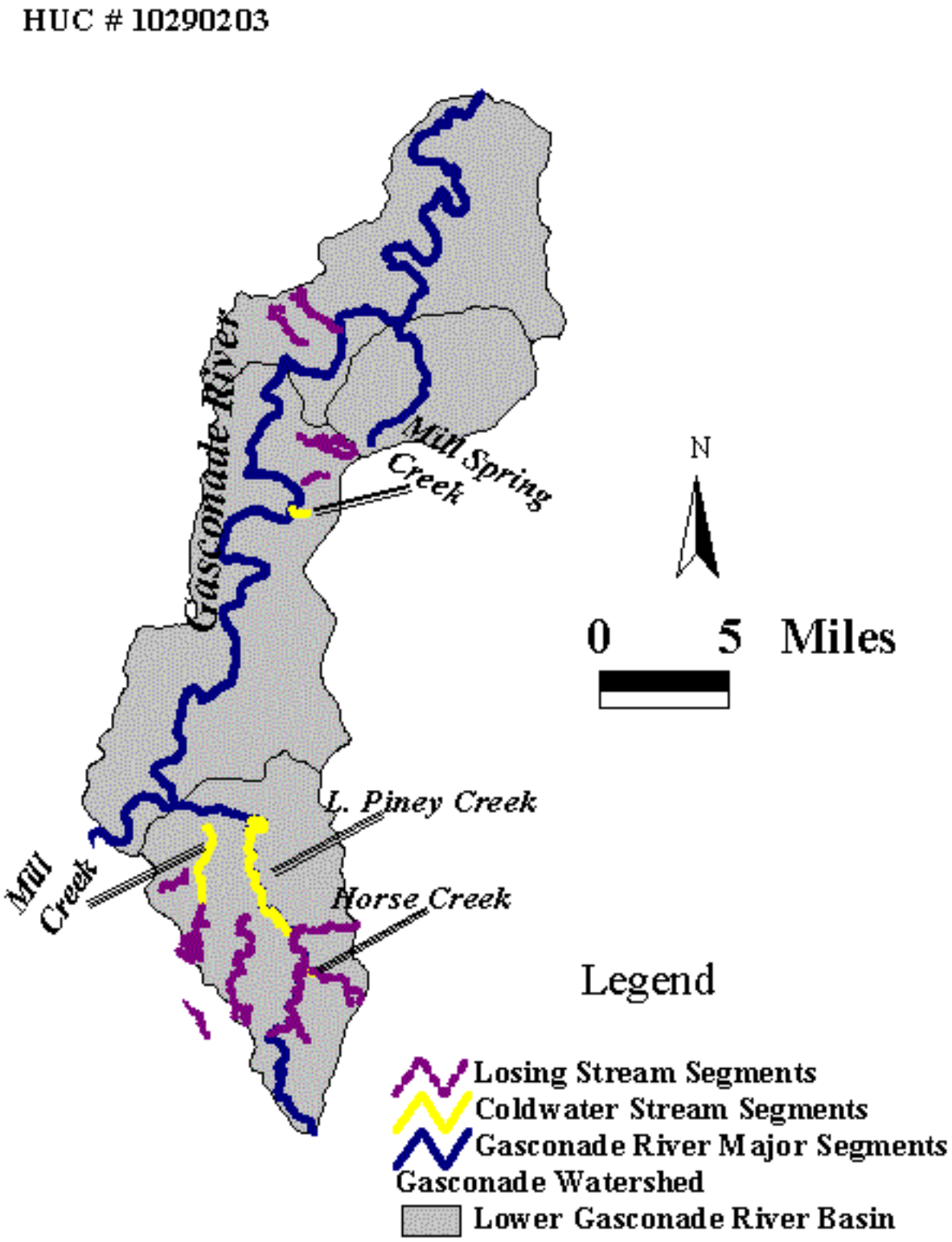


Table 7. Permanence of stream flow (fishable waters) in third-order and larger streams in the Gasconade River watershed (Funk 1968).

Stream Name	Order[1]	Permanent Stream[2]	Intermittent Pools[2]	Total Length Miles[3]
		Miles	Miles	
Gasconade River		263	2	271
Lower Gasconade River Hills HU Code #10290203-040				
First Creek (Gasconade County)	4	1	10	14.5
Brushy Fork Creek (Gasconade)	3		0.5	2.3
Unnamed creek (Gasconade)	4		2	5.3
Richland Creek (Gasconade)	3		0.5	6.4
Second Creek (Gasconade)	5	6.5	6	14.7
Puncheon Creek (Gasconade)	4		4	7.8
Unnamed Creek (Osage-Gasconade)	3		1	2.8
Pin Oak Creek (Gasconade)	3	1	1.5	7.1
Contrary Creek (Osage)	3	1.5	4	9.2
Third Creek HU Code # 10290203-030				
Third Creek	5	3.5	5.5	14.4
Little Third Creek	3		3.5	10.7

Crider Creek	4	5	1.5	10.4
Old Bland Creek	3		3	5.3
Cedar Branch	4		2	9.5
Brushy Creek	3		1	5
Mistaken Creek	3	6	1.5	9.7
Lower Gasconade River **HU Code # 10290203-020**				
Brush Creek (Osage)	4	2.5	2.5	6.6
Unnamed Creek (Osage)	3		1	5.0
Buehler Creek (Osage)	4		1.5	3.5
Spring Creek (Phelps-Maries)	4	5	1	19.2
Dry Creek (Maries)	4	1.5	1.5	9.7
Camp Creek (Phelps)	4		2	7.4
Little Piney Creek **HU Code # 10290203-010**				
Little Piney Creek (Texas-Phelps)	5	19	4.5	43.2
Mill Creek (Phelps)	4	9.5		15.2
Beaver Creek (Phelps)	4		3.5	10.0

Little Beaver Creek (Phelps)	3		3.5	5.4
Unnamed Creek (Phelps)			1.5	
Unnamed Creek (Phelps)			.5	
Roubidoux Creek **HU Code # 10290201-060**				
Roubidoux Creek (Texas-Pulaski)	5	23.5	25.5	
East Fork Roubidoux (Texas)	5		4.5	
Middle Gasconade River **HU Code # 10290201-070**				
Bear Creek (Laclede-Pulaski)	4		12	
Lower Osage Creek **HU Code # 10290201-040**				
Osage Fork (Webster-Laclede)	5	69.5		80.1
Unnamed Creek (Laclede)	3	6		-
Cobb Creek (Laclede)		1	1.5	14.1
Brush Creek (Laclede)		4	2	11.1
Parks Creek (Laclede-Webster)	4	3	2	14.7
Panther Creek (Laclede-Webster)	4	2.5	1.5	-
Centre Creek (Webster)	4	7	5.5	-

Hyde Creek (Webster)	3	4		-
Upper Gasconade River HU Code # 10290201				
Mill Creek (Laclede)	4	2		7.7
Elk Creek (Wright)	4	5	1.5	14.9
Beaver Creek HU Code # 10290201-020				
Beaver Creek (Texas-Wright)	5	26.5	5	35.4
North Fork Beaver Creek (Wright)	4		1.5	4.9
Upper Gasconade River HU Code # 10290201-010				
Whetstone Creek (Wright0	5	11.5	3.5	20.3
Clark Creek (Wright)	4		1	12.3

[1] Stream order taken from 7.5" topographic maps. [2] Taken from Funk 1968.

[3] As determined using hand dividers from 7.5" topographic maps by East Central Region Fisheries personnel.

Table 8. Base-flow (cfs) recession characteristics. The average rate of decrease of stream runoff during periods of no precipitation. Recession data from the period of May through October (Skelton 1970).

			TIME, IN DAYS				
GAGE NO. STREAM, SITE	**PERIOD OF RECORD**	**MINIMUM MEASURED FLOW**	**0**	**10**	**20**	**30**	**40**
6-9277 Gasconade River, Nebo	1942, 1944-47, 1952, 1962-64, 1967	26 A B	45 45	32 23	22 13	16 -	- -
6-9277.5 Osage Fork, Orla	1953, 1962-65, 1967	17 A B	34 34	26 20	19 12	15 -	11 -
6-9278 Osage Fork, Drynob	1942, 1944-47, 1952, 1953, 1956, 1962-67	12 A B	38 38	28 21	20 12	15 -	11 -
6-9280 Gasconade River, Hazelgreen	1930-67	18 A B	100 100	68 46	45 23	31 -	21 -

6-9284.5 Roubidoux Creek, Waynesville	1942-43, 1945-47, 1952, 1062-65, 1967	3.9 A B	22 -	9.0 -	4.0 -	2.2 -	- -
6-9285 Gasconade River, Waynesville	1915-67	44 A B	200 200	120 84	82 49	60 -	48 -
6-9301 Spring Creek, Spring Creek	1953, 1961-65, 1967	12 A B	28 28	21 18	17 12	14 -	- -
6-9309 Little Piney Creek, Yancy Mills	1953, 1962-65, 1967	0.2 A B	12 12	3.0 1.0	0.8 0.2	0.2 -	- -
6-9317 Beaver Creek, Newburg	1961-65, 1967	1.8 A B	4.0 4.0	2.5 1.8	1.6 1.1	1.2 -	- -
6-9333 Mill Creek, Newburg	1955-57, 1961-65, 1967	5.6 A B	8.0 8.0	6.0 5.0	5.0 4.0	4.2 -	- -
6-9320 Little Piney Creek, Newburg	1929-67	24 A B	50 50	37 31	30 23	25 -	- -
6-9335 Gasconade River, Jerome	1924-67	254 A B	600 600	485 415	420 325	370 275	335 255

6-9340 Gasconade River, Rich Fountain	1923-59	275 A B	650 650	550 485	480 390	425 335	380 300

Row A = average recession rate; Row B = maximum recession rate (used during long periods of extremely hot summer weather when evapotranspiration rates are excessive).

Table 9. Annual mean discharge and estimated magnitude and frequency of annual low flow. Period of record is listed except where footnoted (MDNR 1996, USGS 1998).

			DISCHARGE (CFS)			7-DAY LOW FLOW			
GAGE NO. STREAM	**SITE**	**PERIOD OF RECORD**	**Annual Mean**	**Maximum Annual Mean**	**Minimum Annual Mean**	**Q2**	**Q10**	**Q20**	**Slope Index (Q2/ Q20)**
06932000 Little Piney Creek	Newburg, MO.	1929-98	165	391	47	41[1]	25[1]		
06933500 Gasconade River	Jerome, MO.	1903-06, 1923-98	2663	6491	544	470[2]	320[2]	299[3]	1.57
06934000 Gasconade River	Rich Fountain	1921-59, 1986-98	3112	6560	629	520[4]	330[4]		
Roubidoux Creek	Ft. Wood	1964-71				4.5	1.5		
Beaver Creek	nr. Rolla	1949-54	5900			0.3	0.1		
06927800 Osage Fork	DryNob	1962-81		38800	7.2	27	15		

Period of Record (USGS) - [1]1928-1991, [2]1923-91, [3]1905-98, [4]1959-91

Table 10. Flood frequency data from stream gaging stations in the Gasconade River basin (Hauth 1974).

			MAGNITUDE OF FLOOD IN CFS FOR YEARS					
GAGE NO. STREAM SITE	BASIN AREA (MI^2)	SLOPE (FT/MI)	2	5	10	25	50	100
06928000 Gasconade River, Hazelgreen	1,250	3.97	23,600	44,800	60,400	80,900	96,200	111,000
06928500 Gasconade River, Waynesville	1,680	3.18	23,400	41,200	53,600	69,200	80,700	91,800
06931000 Beaver Creek, Rolla	13.7	39.5	1,920	3,110	3,890	4,850	5,530	
06931500 Little Beaver Creek, Rolla	6.41	65.6	1,240	2,340	2,430	5,280	6,060	6,800
06932000 Little Piney Creek, Newburg	200	14.0	6,760	13,400	18,200	25,100	30,300	35,400

06933500 Gasconade River, **Jerome**	2,840	3.01	31,700	55,500	72,000	92,800	108,000	123,000
06934000 Gasconade River, **Rich Fountain**	3,180	2.68	29,400	48,100	60,400	75,600	86,400	96,700